Wildlife Management in the National Parks: Questions in Search of Answers

R. Gerald Wright

Ecological Applications, Vol. 9, No. 1 (Feb., 1999), 30-36.

Stable URL:
http://links.jstor.org/sici?sici=1051-0761%28199902%299%3A1%3C30%3AWMITNP%3E2.0.CO%3B2-O

Ecological Applications is currently published by The Ecological Society of America.

Ecological Applications, 9(1), 1999, pp. 30–36

WILDLIFE MANAGEMENT IN THE NATIONAL PARKS: QUESTIONS IN SEARCH OF ANSWERS

R. GERALD WRIGHT

U.S. Geological Survey, Cooperative Fish and Wildlife Research Unit, Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho 83844-1136 USA

Abstract. The history of wildlife management in the national parks can be traced in the ungulate management policies of the National Park Service (NPS). These policies have, at various times, embraced total protection at the expense of other species, authorized culling to maintain explicit population levels, and since 1970 advocated natural regulation combined with limited human interference with park ecosystems. Current policy has had important ramifications for ungulate populations in parks as discussed in the preceding papers in this Invited Feature. This paper synthesizes those papers, interpreting the answers to three questions in relation to NPS wildlife management: (1) how does this management differ from other public resource managers; (2) can thresholds for management intervention be established for the species of concern; and (3) is scientific knowledge adequate to make and implement management decisions? The paper finds that NPS management does differ significantly from other federal land management and state wildlife management agencies, which is a factor complicating coordination and understanding of management approaches. It concludes that management thresholds can be and have been established in the past; however, given the ecological complexity of parks, scientific support for such thresholds will probably always be inadequate. This situation argues for an experimental management approach with continued monitoring of conditions both in and outside the parks.

Key words: elk; Isle Royale, Michigan (USA); national parks; ungulates; wildlife management policies; Yellowstone National Park (USA).

INTRODUCTION

The historical context

Of all the resources contained within the United States National Park system, wild animals are indisputably among the most important, both to visitors and park managers, and are as a consequence a dominant management concern. This was true when the first parks were created in the late 1800s, and it is equally true today (Wright 1992).

The first national parks in the United States were novel experiments built on an uncertain foundation. Park advocates had little understanding of how parks should function and what they should look like. Early park advocates therefore relied on the models that existed, such as English and American game preserves; intensively managed areas that focused on the preservation of selected species (Palmer 1912). These models were generally predicated on the assumption that the status quo, or existing natural systems could be maintained or enhanced through protection of the resources (Wright 1996*b*). The goal of early park management was thus to protect species considered to be desirable, primarily large ungulates, and to eliminate undesirable species or processes which threatened the desired species. These goals were in concert with the prevailing ecological thinking of the times (Christensen 1988). The management methods used to achieve these goals included artificial feeding, control of predators, fire suppression, and the elimination of disease and pathogens (Graber 1983).

These management approaches were, at least initially, remarkably successful in the early western parks like Yellowstone where native ungulates had been greatly diminished by several decades of rampant slaughter by market hunters and trappers (Reiger 1975). And although data are few, there seems to be little doubt that by the early 1930s there were substantially more mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and bison (*Bison bison*) in most western parks than there had been a few decades earlier (Wright 1992). The increase in numbers was immensely gratifying to park personnel. However, within a few years, this satisfaction began to be tinged with trepidation that the basic assumption of this management model might be flawed. Scientists were realizing that simple protection could not assure the maintenance of the status quo in these complex ecosystems (Rush 1929, Cahalane

Manuscript received 14 April 1997; revised 9 October 1997; accepted 14 October 1997; final version received 17 December 1997. For reprints of this Invited Feature, see footnote 1, p. 1.

1941), and they began to express the opinion that some ungulate herds might need to be reduced in order to preserve habitat conditions (Ratcliff 1941, Cahalane 1943). Managers were in turn frightened by the prospect that if the herds continued to grow, species that had been nurtured and protected for decades could now end up starving on denuded ranges, thereby bringing the wrath of the public upon them (Dixon and Sumner 1939). These concerns were fueled by accounts of other large ungulate die-offs such as on the Kaibab Plateau in Arizona (Rasmussen 1941). Concerns about overpopulations were supported by the first ever set of scientific surveys conducted in the parks (Wright et al. 1933). The surveys suggested that the capacity of the winter range in many parks to support large ungulate species was decreasing. They also advocated an end to predator control in parks. At the time, major ungulate predators such as the wolf (*Canis lupus*) and cougar (*Felis concolor*) had been reduced to virtual extinction in many parks, and thus no longer played an important role in controlling ungulate populations (Cahalane 1939).

Programs to cull ungulate species by shooting and translocation were seen as a solution to the problem of overabundant animals and were initiated in several western parks. The magnitude of some of these programs was startling. For example, >15 000 elk were removed from Yellowstone between the mid-1930s and mid-1960s (Houston 1982). However, in most parks removals were much less and the culling took place sporadically.

Culling programs in the western parks, including Yellowstone, Rocky Mountain, Glacier, and Yosemite, ceased in the late 1960s (Wright 1992). There were several reasons why the animal removal programs were stopped, but the main impetus was growing opposition from humane organizations and sporting groups that were fueled by magazine and television accounts of the details of the programs (Allard 1967). Concern over the reduction programs in parks was the impetus for the establishment, by the Secretary of the Interior, of the Special Advisory Board on Wildlife Management in the National Parks in 1962. The report of this committee (Leopold et al. 1963) was a discussion of how parks should be managed to maintain a reasonable illusion of a primitive state, and where intervention might be necessary in order to maintain that condition (Schullery 1989). One area where intervention was deemed necessary was the control of overabundant ungulates in the parks. On 2 May 1963, the Secretary of the Interior approved the recommendations of the Advisory Board and directed that they be incorporated in the administrative policies of the National Park Service (NPS).

Public pressure for cessation of wildlife control programs however continued to increase, and as a consequence, the U.S. Senate held field hearings on the control of elk in Yellowstone in March 1967. Faced with intense political pressure such as threats to cut the NPS budget, the NPS agreed to immediately stop killing elk in the park (U.S. Senate 1967). This decision was soon applied to other parks, and made in spite of the fact that NPS administrative policies at the time, reflecting the recommendations of the Leopold Report, supported the control of wildlife populations "when necessary to maintain the health of the species, the native environment, and the scenic landscape" (NPS 1970:25).

To address this new management direction, NPS managers adopted the term "natural regulation." Under this concept, ungulate populations were interpreted as being self-regulating units. "They regulated their own mortality and compensated natality in relation to available winter food and their population size" (Cole 1971: 419). As with other important wildlife issues of this century such as the ban on hunting in parks and the cessation of predator control in parks, Yellowstone found itself at the forefront of the implementation of natural regulation. The implementation of natural regulation in the park has subsequently been described as an "experiment" (e.g., Despain et al. 1986, Huff and Varley 1999 [this feature] although I have not been able to locate a reference documenting the origin of that phrase. Houston (1982) for example, characterized his definitive evaluation of elk in Yellowstone as a set of interrelated research hypotheses, but did not use the term experiment. Sinclair in the forward to Houston's (1982) book referred to the need to design management actions as experiments but indicated only that Houston's studies followed the principle of experimental management.

Despite an inability to identify its origin, one can infer from the literature that the experiment undertaken at Yellowstone was indeed an evaluation of the new management direction, even if it was not a controlled design experiment. In the words of the then Chief of Research at Yellowstone, it was a test of the hypothesis ". . . that populations of native ungulates cannot, without overriding successional influences or habitat limitations imposed by man, progressively reduce food sources that limit their own densities" (Cole 1971: 420).

The main characteristic of the new management direction was that it placed less emphasis on human interference with the components and processes of park ecosystems. In this sense, it can be considered to be a return to the older protection paradigm, albeit with a stronger theoretical foundation and embodying a greater understanding of natural systems. More recently, this approach has been termed ecological process management, where the object is to "allow the ecological processes of nutrient cycling, plant succession, fire, decomposition, competition, predation, symbiosis, birth and death, to operate unimpeded by human interven-

tion" (Boyce 1991:190). Implied in this approach was the idea that such processes would ultimately serve to limit or control ungulate populations. This idea seems in keeping with the most recent NPS Management Policies which states that "Natural processes will be relied on to control populations of native species to the greatest extent possible" (NPS 1988 section 4:6).

All large national parks employ the concept of ecological process management to some extent, even if it is limited to only a few natural processes such as succession and nutrient cycling. However, the number of parks that support naturally regulated ungulate populations is much more limited. Robisch and Wright (1995) surveyed the 28 largest national parks containing 95 ungulate populations in the continental United States and Denali National Park, Alaska, on this issue. Using relatively strict criteria, they found only 14 populations in 10 parks had ungulate populations that could be considered to be naturally regulated. Thus it could be argued that the concept can be achieved at least for some nonmigratory species in large parks such as Roosevelt elk (*Cervus elaphus roosevelti*) in the Hoh River drainage of the Olympic (Jenkins and Starkey 1984) or for species with relatively restricted ranges such as bighorn sheep (*Ovis canadensis*). Robisch and Wright (1995) however found that in most cases, parks were not large enough to support naturally regulated populations on all seasonal ranges and most did not have the necessary compliment of predator species to help control ungulates.

Given the absence of factors needed to support ecological process management and the existence of facilities that support recreational uses in parks, it is prudent to ponder whether or not these park ecosystems are in fact natural. I don't believe there is any one answer to that question. On one hand, parks are certainly more "natural" than the managed landscapes common throughout the rest of the country. However, scientists are also continually gaining new appreciation for the degree to which these landscapes have been utilized by native peoples over the past 10 000 yr and are more and more accepting the fact that they were never pristine wilderness (Rolston 1990).

The questions

Against this background, authors of three papers in this symposium were asked to examine the ramifications of NPS management on three species of ungulates in different parks: elk in Yellowstone; white-tailed deer (*Odocoileus virginianus*) in eastern parks; and moose (*Alces alces*) in association with wolves at Isle Royale National Park. The authors were asked to address three questions in relation to NPS wildlife management approaches: (1) how does it differ from the management objectives of other public resource managers; (2) if necessary, can thresholds for management intervention be established in order to effectively manage the species of concern; and (3) is scientific knowledge adequate to make and implement management decisions.

Discussion

The first question was easy to answer. NPS wildlife management policies are different from the mandates of most responsible state agencies. State wildlife agencies typically manage for population size and quality (e.g., large trophy males), whereas the NPS has no overt management emphasis other than assuring that populations are free of unwarranted unnatural disturbances. States also manage populations on large geographic scales, i.e., often entire herd boundaries, whereas the NPS manages at much smaller scales, i.e., individual parks.

These differences in approaches have led to misunderstanding and to criticism both from individual scientists and from state wildlife management agencies. Recently, much of the criticism of NPS management has stemmed from concern over increases in ungulate populations in a number of parks. Scientific critics (e.g., Wagner and Kay 1993, Wagner et al. 1995) point out that it was the processes—which were operational prehistorically such as aboriginal hunting, free dispersal, and greater predation, but are absent today—that served to limit the density of ungulate populations. They believe that the natural processes that still operate in parks are insufficient to limit ungulate populations, and as a result these populations are reaching densities at which they significantly impact their environment. These impacts include the diminishment of aspen stands (*Populus tremuloides*) and riparian areas in Yellowstone (Chadde and Kay 1991). Changes in the structure and composition of coniferous forests on Isle Royale attributable to moose browsing have also been documented (Risenhoover and Mass 1987). In contrast, Houston (1982) also used repeat photography studies in the Yellowstone ecosystem over the last 100 yr to show that there have been no substantive ecological changes that could not be attributed to fire suppression or climate change.

Criticism from state game departments stems largely from the fact that these agencies feel they have little say about how wildlife is managed in parks. From its beginning, the NPS has maintained exclusive jurisdiction over the management of wildlife in parks. And, although legally contested by individual state game departments, court decisions have uniformly supported the right of the NPS to own and manage wildlife on its lands (Buono 1997). The jurisdictional issue as well as the different management mandates has often resulted in less than cordial relations between the NPS and state game departments (Skibby 1960). The situation illustrates a fundamental difference between the NPS and other federal land management agencies. The U.S. Forest Service and Bureau of Land Management routinely defer wildlife management responsibilities on

the lands they manage to the respective states. The U.S. Fish and Wildlife Service manages migratory waterfowl both on and off of federal refuges, but also defers management of other game species to the states. The difference between the NPS and other federal agencies often poses complications in situations where parks border other federal lands and where animals move in and out of the parks. A case in point is Mount Rainier National Park where high densities of Rocky Mountain elk (transplanted from Yellowstone between 1912 and 1933) concentrate on fragile subalpine meadows during the summer but move out of the park into state, private, and Forest Service lands in the winter. It is on these lands, depending on harvest regulations and timing of movements, where herd control can best be accomplished, but this requires the cooperation of the Washington State Game Department (Bradley and Driver 1981).

The issue of state involvement has recently resurfaced with the increases in white-tailed deer populations throughout the eastern U.S. Since these increases often occurred first in parks and because the deer tended to be more visible in parks, the parks have been the center of attention from state agencies. These agencies would generally like to see parks reduce deer numbers and ideally would like to see that reduction carried out by local hunters (Wright 1993). The NPS has consistently rejected that argument and it has been supported by scientists who point out that the critics of current NPS management are merely seeking a return to the management policies of the past, practices which would lock the NPS into an on-going program of human intervention and extensive manipulation of park ecosystems (McNaughton 1996).

The answer to the second question of whether necessary thresholds for intervention can be established is less clear, at least in the comments in the three papers. Porter (1996) elsewhere has pointed out that, as with elk in Yellowstone, demands for intervention to control white-tailed deer have been based on the perception that the natural processes that formerly limited growth are no longer effective. He maintained that such processes do in fact still work. However because of habitat fragmentation and increased protection, the carrying capacity for white-tailed deer in many areas of the East has increased markedly. Porter and Underwood (this issue) point out that defining points of intervention in a park is difficult, because it implies that a goal has been set for that ecosystem. Goals in turn infer value judgments, and they feel the NPS has not defined goals well enough to identify meaningful thresholds, at least in natural area parks.

Goals for historical parks may be easier to define. For example, at Gettysburg National Military Park, research has shown that white-tailed deer are limiting the park's ability to meet cultural resource goals such as the maintenance of crop lands and historic woodlots essential to interpreting the battle of 1863 (Vecellio et al. 1994). In this case it was thus feasible for the park to establish a threshold for intervention. Intervention took the form of controlled deer harvests in the park in 1995 and 1996.

Peterson (1999, this feature) points out that the question of *if* and *when* to intervene in the face of a wolf decline or extirpation at Isle Royale National Park is not an issue of biology, but one that also involves an interpretation of the management goals of the park. Although wolves arrived in the park by natural means, apparently traveling over the ice from the Canadian shore, similar opportunities are minimal today because higher lake temperatures inhibit ice formation, and development along the Canadian shoreline would disrupt future migration. Thus, replacement of wolves in the park would have to be carried out by park managers. Isle Royale is a park with a long history of nonintervention in terms of resource management (to the extent that it is closed in winter), and Peterson is uncertain whether society would favor a purposeful wolf introduction.

The issue of *if* and *when* to control elk numbers in Yellowstone is complicated by several factors. For example, there is no clear agreement as to whether current elk numbers in Yellowstone are within the range of historical estimates. It does appear that the lack of wolf predation for most of this century has played a major role in elk population dynamics, and as wolf numbers grow, if they grow, potential thresholds for intervention may change (Varley and Brewster 1992).

Past Yellowstone managers did define explicit "thresholds for intervention." From the 1930s through 1968 in-park reductions helped limited elk numbers to ~4000 elk/yr (a number that lacks clear scientific or social justification). To achieve this goal, an average of 1600 elk were removed each year. These numbers give some indication of the amount of effort that might be needed to maintain elk populations at a defined level. Bison were likewise managed intensively to achieve desired population levels and herd health and for many years were rounded-up and held over winter in corrals in the Lamar Valley (Cahalane 1944, Wright 1992).

Huff and Varley (1999), however, question whether intervention to control ungulate species would be advisable at this time as it would likely disrupt what they have termed the "on-going experiment." While it is wise to question the efficacy of intervention at this time, couching it in the rhetoric of disrupting an "on-going experiment" is not. As indicated earlier, the application of the word "experiment" to what is happening at Yellowstone has ambiguous origins and it is probably not an appropriate term to use. What has been on-going at Yellowstone since the cessation of control actions has been interesting and scientifically informative, but it does not qualify as an experiment. While

several hypotheses have been framed over the years, there have been few if any replicated controls.

Whether learned from experiment or not, however, one can argue that there probably is a scientific knowledge base sufficient to establish thresholds for management actions for most ungulate species if it were adequately synthesized. However, the establishment of ecological thresholds is only one part of the equation. Social values also need to be considered, and they can be exceedingly complex. Reaching consensus on both ecological and social values will be very difficult. Ecological understanding could be improved if the results of research conducted in one park were more commonly extrapolated to similar situations in other parks. Unfortunately, this rarely happens (National Research Council 1992). The extensive research conducted on deer populations and their impacts on cultural resources at Gettysburg (Storm et al. 1989) is a case in point. This study was instrumental in supporting the recent culling actions in that park, but it has so far had little effect on NPS policies service-wide. For example, although extensive research has been conducted on the impact of white-tailed deer at Saratoga National Historic Site (Underwood et al. 1994); because information about the characteristics of the landscapes in 1777 (when the Revolutionary War battles were fought) was less precise, no management actions have been taken.

Isle Royale is unique among parks and most other natural areas, in that it has a quality, long-term scientific information base that is adequate to address most questions relative to intervention at least as far as moose and wolves are concerned (Wright 1996*a*). However as Peterson (1999) pointed out this long time span has also served to show the complexity of the issue, because at different points in the period, different perspectives of what is going on have emerged. Implied, if not overtly stated, was the fact that if the research had terminated at any one of these previous points, biological understanding of the system would be far different and probably flawed. Peterson (1999) feels that after 38 yr of research, a clear understanding of the factors that influence moose population growth is only now emerging.

Concluding Thoughts

Peterson's (1999) concluding thoughts on finally gaining a clear understanding of what is happening on Isle Royale demand further comment. While his optimism may be premature, the work at Isle Royale does serve to show how complex ecosystems can be, and the time and money one needs to invest in order to understand them. Should there be little wonder then, why so many questions persist about a park the size of Yellowstone? The Isle Royale findings raise the tantalizing issue of whether there will ever be enough knowledge to adequately manage the complex ecosystems that make up our national parks. Isle Royale is admittedly a "simple" system; an isolated island with one major predator and one major prey species and little human disturbance. Yet even there after 38 yr of intensive study, there are still questions about how the system functions and will do so in the future (Wright 1996*a*).

How then can one reasonably hope to have knowledge adequate to define thresholds for possible intervention in a park like Yellowstone? This is a park with 2.5 million visitors a year, a long history of human use and disturbance, seven major large ungulate species and three major large carnivores. Despite many years of research, we are only now learning of the myriad ways that ungulates can change ecosystems ranging from modifying nutrient cycling, influencing primary production, altering patch dynamics, and affecting abiotic disturbance (Hobbs 1996). In addition, all of these modifications may occur at several spatial scales (Huntly 1991).

Huff and Varley (1999) write of witnessing the results of the natural process management "experiment" as it proceeds to completion. It is not clear what they envision at this point. One possible end point could be an equilibrium of ungulate populations at some level that does not seriously impact the existing forage base. A second possibility would be fluctuating populations changing in response to changes in annual weather, climate, and food availability. Interpreting either conclusion is difficult because of a paucity of understanding of the relationships between population dynamics of ungulates and ecosystem processes; and thus how would this situation be recognized as the end of the experiment?

It is doubtful that we will ever know enough to say that the so-called experiment is completed in Yellowstone or other parks. However, this does not mean that the NPS should abandon support for continued research, and in fact the agency probably should expand the scope of research. It can be argued that some of the difficulties in interpreting conditions at Yellowstone have been caused by the limited purview of the research, i.e., most research conducted relative to conditions at Yellowstone have been conducted within the boundaries of the park and represents only a part of the larger Yellowstone ecosystem. An approach that includes comparative monitoring of conditions outside the park might be very revealing. As indicated by Porter and Underwood (1999 [this Invited Feature]), the NPS cannot effectively achieve its goals without better science or without considering the conditions on adjacent lands, but neither can it afford to wait for all of the questions about ecosystem dynamics to be answered before undertaking some management actions. Management goals and objectives need to be continually evaluated, and actions can and should proceed even in the absence of complete knowledge. However, management should be done in close association with

science. An adaptive management approach (Walters 1986) linking management to experimentation and monitoring provides the best opportunity to increase knowledge and improve park management.

ACKNOWLEDGMENTS

I am grateful to James Peek for his insights on these issues and for the helpful review comments by Edward Starkey, Hal Salwasser, David Parsons, and an anonymous reviewer.

LITERATURE CITED

Allard, W. A. 1967. Yellowstone wildlife in winter. National Geographic **132**:637–631.

Bradley, W. P., and C. H. Driver. 1981. Elk ecology and management perspectives at Mount Rainier National Park. Report CPSU/UW 81-2, Cooperative Park Studies Unit, University of Washington Press, Seattle, Washington, USA.

Boyce, M. R. 1991. Natural regulation or the control of nature? Pages 183–208 *in* R. B. Keiter and M. R. Boyce, editors. The greater Yellowstone ecosystem. Yale University Press, New Haven, Connecticut, USA.

Buono, F. 1997. Managing wildlife in the parks: the legal basis. The George Wright Forum **14**(1):18–24.

Cahalane, V. H. 1939. The evolution of predator control in the national parks. Journal of Wildlife Management **3**:229–237.

———. 1941. Wildlife surpluses in the national parks. Transactions North American Wildlife Conference **6**:355–361.

———. 1943. Elk management and herd regulation—Yellowstone National Park. Transactions North American Wildlife Conference **8**:95–101.

———. 1944. Restoration of wild bison. Transactions North American Wildlife Conference **9**:135–143.

Chadde, S., and C. E. Kay. 1991. Tall-willow communities on Yellowstone"s northern range: a test of the "natural-regulation" paradigm. Pages 231–262 *in* R. B. Keiter and M. R. Boyce, editors. The greater Yellowstone ecosystem. Yale University Press, New Haven, Connecticut, USA.

Christensen, N. L. 1988. Succession and natural disturbance: paradigms, problems, and preservation of natural ecosystems. Pages 62–86 *in* J. K. Agee and D. R. Johnson, editors. Ecosystem management for parks and wilderness. University of Washington Press, Seattle, Washington, USA.

Cole, G. F. 1971. An ecological rationale for the natural or artificial regulation of native ungulates in parks. North American Wildlife and Natural Resources Conference **36**: 417–425.

Despain, D., D. Houston, M. Meagher, and P. Schullery. 1986. Wildlife in transition. Roberts Rinehart, Boulder, Colorado, USA.

Dixon, J. S., and E. L. Sumner. 1939. The deer problem, deer trapping and deer removal at Zion Canyon, Utah. Transactions North American Wildlife Conference **4**:231–235.

Graber. D. M. 1983. Rationalizing management of natural areas in national parks. George Wright Forum **3**(4):48–56.

Hobbs, N. T. 1996. Modification of ecosystems by ungulates. Journal of Wildlife Management **60**:695–713.

Houston, D. B. 1982. The northern Yellowstone elk herd: ecology and management. Macmillan, New York, New York, USA.

Huff, D. E., and J. D. Varley. 1999. Natural regulation in Yellowstone National Park's northern range. Ecological Applications **9**:17–29.

Huntly, N. 1991. Herbivores and the dynamics of communities and ecosystems. Annual Review of Ecology and Systematics **22**:477–503.

Jenkins, K. J., and E. E. Starkey. 1984. Habitat use by Roosevelt elk in unmanaged forests of the Hoh Valley, Washington. Journal of Wildlife Management **48**:642–646.

Leopold, A. S., S. A. Cain, C. M. Cottam, and I. Gabrielson. 1963. Wildlife management in the national parks. Transactions North American Wildlife and Natural Resources Conference **28**:28–45.

McNaughton, S. 1996. Book review: wildlife policies in the U.S. national parks. Journal of Wildlife Management **60**: 685–687.

NPS (National Park Service). 1970. Administrative policies for natural areas of the National Park System. U.S. Government Printing Office. Washington, D.C., USA.

———. 1988. Management Policies. U.S. Government Printing Office. Washington, D.C., USA.

National Research Council. 1992. Science and the national parks. National Academy Press, Washington, D.C., USA.

Palmer, T. S. 1912. National reservations for the protection of wildlife. USDA Circular Number 87. Washington, D.C., USA.

Peterson, R. O. 1999. Wolf–moose interaction on Isle Royale: the end of natural regulation? Ecological Applications **9**:10–16.

Porter, W. F. 1996. Management of overabundant species in protected areas: the white-tailed deer as a case example. Pages 223–248 *in* R. G. Wright, editor. National Parks and Protected Areas. Blackwell, Cambridge, Massachusetts, USA.

Porter, W. F., and H. B. Underwood. 1999. Of elephants and blind men: deer management in the U.S. National Parks. Ecological Applications **9**:3–9.

Rasmussen, D. I. 1941. Biotic communities of the Kaibab Plateau, Arizona. Ecological Monographs **11**:229–275.

Ratcliff, H. M. 1941. Winter range conditions in Rocky Mountain National Park. Transactions North American Wildlife Conference **6**:136–140.

Reiger, J. F. 1975. American sportsmen and the origins of conservation. Winchester, New York, New York, USA.

Risenhoover, K. L., and S. A. Mass. 1987. The influence of moose on the composition and structure of Isle Royale forests. Canadian Journal of Forest Research **17**:357–364.

Robisch, E., and R. G. Wright. 1995. A survey of ungulate management in selected U.S. national parks. Natural Areas Journal **15**:117–123.

Rolston, H., III. 1990. Biology and philosophy in Yellowstone. Biology and Philosophy **5**:241–258.

Rush, W. 1929. What is to become of our northern elk herd? American Forests and Forest Life **35**:12–17.

Schullery, P. 1989. Feral fish and kayak tracks: thoughts on the writing of a new Leopold Report. George Wright Forum **6**(4):41–47.

Skibby, E. J. 1960. Big game hunting in national parks. Proceedings Western Association of State Game and Fish Commissioners **40**:91–93.

Storm, G. L., R. H. Yahner, D. F. Cottom, and G. M. Vecellio. 1989. Population status, movements, habitat use and impact of white-tailed deer at Gettysburg National Military Park, Pennsylvania. National Park Service Technical Report NPS/MAR/NRTR-89.043. Philadelphia, Pennsylvania, USA.

Underwood, H. B., K. A. Austin, W. F. Porter, R. L. Burgess, and R. W. Sage. 1994. White-tailed deer and vegetation at Saratoga National Military Park. National Park Service Technical Report NPS/NAROSS/NRTR/95–28. Boston, Massachusetts, USA.

U.S. Senate. 1967. Hearings before a Subcommittee on Appropriations. U.S. Senate: First Session on Control of Elk Populations in Yellowstone National Park. U.S. Government Printing Office. Washington, D.C., USA.

Varley, J. D., and W. G. Brewster. Editors. 1992. Wolves for Yellowstone? A report to the United States Congress, Vol-

ume IV Research and Analysis. National Park Service, Yellowstone National Park, Mammoth, Wyoming, USA.

Vecellio, G. M., R. H. Yahner, and G. L. Storm. 1994. Crop damage by deer at Gettysburg Park. Wildlife Society Bulletin **22**:89–93.

Wagner, F. H., R. Foresta, R. B. Gill, D. R. McCullough, M. R. Pelton, W. F. Porter, and H. Salwasser. 1995. Wildlife policies in the U.S. National Parks. Island Press, Washington, D.C., USA.

Wagner, F. H., and C. E. Kay. 1993. "Natural" or "healthy" ecosystems? Are U.S. National parks providing them? Pages 251–264 *in* M. J. McDonnell and S. T. A. Pickett, editors. Humans as components of ecosystems: the ecology of subtle human effects and populated areas. Springer-Verlag, New York, New York, USA.

Walters, C. J. 1986. Adaptive management of renewable resources. Macmillan, New York, New York, USA.

Wright, G. M., J. S. Dixon, and B. H. Thompson. 1933. Fauna of the national parks of the United States. Fauna Series 1. U.S. Government Printing Office, Washington, D.C., USA.

Wright, R. G. 1992. Wildlife research and management in the national parks. University of Illinois Press, Urbana, Illinois, USA.

Wright, R. G. 1993. Wildlife management in parks and suburbs: alternatives to sport hunting. Renewable Resources Journal **11**(4):18–23.

Wright, R. G. 1996*a*. Moose and wolf populations in Isle Royale National Park. Pages 74–95 *in* W. L. Halvorson and G. E. Davis, editors. Ecosystem management in the national parks. University of Arizona Press, Tucson, Arizona, USA.

———. 1996*b*. The origin and purpose of national parks and protected areas. Pages 1–14 *in* R. G. Wright, editor. National Parks and Protected Areas. Blackwell, Cambridge, Massachusetts, USA.